REMARKS

Applicants are amending their claims in order to further clarify the definition of various aspects of the present invention. Specifically, Applicants have amended each of the independent claims (that is, claims 1, 2, 21 and 25) to make clear that the at least one optical waveguide (a) having the curved structure, is at least one optical waveguide of the at least one incident light waveguide (A); and to recite that a branching ratio between quantities of light branched into each of the at least two of the output light waveguides (B) is substantially equal. In connection with this latter amendment of each of claims 1, 2, 21 and 25, note, for example, claims 7 and 15 of the claims previously considered in the above-identified application. Applicants have amended claims 7 and 15, to delete therefrom recitation of the branching ratio now incorporated in claims 1, 2, 21 and 25. Applicants have amended claim 2 to delete the "+" in line 9 thereof.

The concurrently filed RCE Transmittal is noted. In view of the filing of this RCE Transmittal, entry of the present amendments is clearly proper, notwithstanding the Finality of the Office Action dated September 3, 2009. Moreover, it is respectfully submitted that the present amendments constitute the necessary Submission for this RCE Transmittal.

In view of the amendment of claim 2, it is respectfully submitted that the objection to claim 2, set forth in Item 2 on page 2 of the Office Action dated September 3, 2009, is moot.

Applicants respectfully submit that all of the claims presented for consideration by the Examiner patentably distinguish over the teachings of the reference applied by the Examiner in rejecting claims in the Office Action dated

September 3, 2009, that is, the teachings of the U.S. patent to Ido, No. 6,236,784, under the provisions of 35 USC 103.

It is respectfully submitted that the teachings of this reference as applied by the Examiner would have neither disclosed nor would have suggested such a light branching optical waveguide, or such optical device having such light branching optical waveguide, as in the present claims, including, inter alia, wherein the light branching optical waveguide includes at least one incident light waveguide (A) optically connected to one end of a multi-mode optical waveguide, with light of a basic mode propagating in the at least one incident light waveguide (A) entering on the geometrical central axis of the multi-mode optical waveguide, and output light waveguides (B), larger in number than the number of incident light waveguide(s) (A), optically connected to the other end of the multi-mode optical waveguide; at least one optical waveguide (a), of the at least one incident light waveguide (A), having a curved structure, and with an intensity distribution of light entering from this optical waveguide(s) (a) being asymmetric with respect to a geometrical central axis of this optical waveguide(s) (a); and with light having a wavelength entering at least two of the output light waveguides (B) from the multi-mode optical waveguide, so as to branch the light from the multi-mode optical waveguide having the same wavelength into each of the at least two of the output light waveguides (B), as in claims 1-3; and (i) an extended line of the geometrical central axis of the at least one optical waveguide (a) does not coincide with a geometrical central axis of the multi-mode optical waveguide (see claims 1 and 3), and/or (ii) a core shape of the multi-mode optical waveguide is asymmetric with respect to a geometrical central axis of the multi-mode optical waveguide (see claim 2).

Furthermore, it is respectfully submitted that the teachings of this applied reference would have neither disclosed nor would have suggested such a light branching optical waveguide, or such optical device having such light branching optical waveguide, as in the present claims, having features as discussed in the immediately preceding paragraph herein, in connection with claims 1-3, and, additionally wherein the waveguide is characterized in that a branching ratio between quantities of light branched into each of the at least two of the output light waveguides (B) are substantially equal. See claims 1 and 2.

Furthermore, it is respectfully submitted that the teachings of the reference as applied by the Examiner would have neither disclosed nor would have suggested such a method of manufacturing a light branching optical waveguide as in the present claims, the light branching optical waveguide having structure including the waveguides (A), (B) and (a), and the multi-mode optical waveguide, as discussed in the immediately prior two paragraphs, the at least one optical waveguide (a), of the at least one incident light waveguide (A), having a curved structure, with light having a wavelength entering at least two of the output light waveguides (B) from the multi-mode optical waveguide, so as to branch the light from the multi-mode optical waveguide having the same wavelength into each of the at least two of the output light waveguides (B), a branching ratio between quantities of light branched into each of the at least two of the output light waveguides (B) being substantially equal, as discussed previously in connection with claims 1 and 2; the method including positioning the at least one optical waveguide (a), which has the curved structure, such that an extended line of the geometrical central axis of the at least one optical waveguide (a) does not coincide with a geometrical central axis of the multi-mode

optical waveguide (see claim 21), or wherein the method includes forming a core shape of the multi-mode optical waveguide to be asymmetric with respect to a geometrical central axis of the multi-mode optical waveguide (see claim 25).

As will be discussed in more detail infra, according to the present invention the at least one optical waveguide (a), of the incident light waveguides (A), has a curved structure, and problems addressed by the present invention arise due to this optical light waveguide (a) having a curved structure. Contrary to the contention by the Examiner, Ido has all incident light waveguides with linear (not curved) structures, and problems addressed by the present invention would not arise in connection with the structure of Ido.

Moreover, according to the present invention, the branching ratio between quantities of light branched into each of the at least two of the output light waveguides (B) is substantially equal (that is, a branching ratio of 1:1 in branching of light is achieved). Noting that Ido provides an asymmetric Y branch optical waveguide, and specifically teaches a branching ratio which is not 1:1, it is respectfully submitted that this reference would have neither disclosed nor would have suggested, and in fact would have taught away from, the present invention, including wherein a branching ratio between quantities of light branched into each of the at least two of the output light waveguides (B) is substantially equal.

Furthermore, it is respectfully submitted that the teachings of the applied reference would have neither disclosed nor would have suggested such light branching optical waveguide as in the present claims, having features as discussed previously in connection with claims 1-3, and, additionally, having features as in the dependent claims, dependent ultimately on claims 1 and 2, including, inter alia (but

not limited to), wherein an optical central axis having a peak intensity in the intensity distribution of light entering into the multi-mode optical waveguide from the at least one optical waveguide (a) substantially coincides with the geometrical central axis of the multi-mode optical waveguide (see claims 4 and 12); and/or wherein the core shape of the multi-mode optical waveguide has a notch at at least one of its side edges (see claims 5 and 13), particularly wherein such notch is obtained by a technique as in claims 6 and 14, especially with a shape of the notch as in claims 6 and 14; and/or wherein the at least one incident light waveguide (A) includes one incident light waveguide and the output light waveguides (B) include at least two output light waveguides (see claims 7 and 15); and/or wherein at least one of the at least one incident light waveguide (A) and the output light waveguides (B) include a single-mode optical waveguide (note claims 8 and 16); and/or materials of the core or clad of the multi-mode optical waveguide, as set forth in claims 9, 10 and 17; and/or offset distance between the extended line of the geometrical central axis of the at least one optical waveguide (a) and the geometrical central axis of the multi-mode optical waveguide, as in claims 19 and 20.

In addition, it is respectfully submitted that the teachings of the applied reference would have neither disclosed nor would have suggested such a method as in claims 21 and 25, and including additional features as in claims dependent on claims 21 and 25, including (but not limited to) wherein the at least one incident light waveguide (A) is one incident light waveguide (A), the at least one optical waveguide (a) is one optical waveguide (a), and the output light waveguides (B) are at least two in number (see claims 24 and 28).

Moreover, it is respectfully submitted that the teachings of the applied reference would have neither disclosed nor would have suggested such light branching optical waveguide, or such method, as in the present claims, having features as discussed previously in connection with claims 1, 2, 21 and 25, and, moreover, wherein the at least one optical waveguide (a) is directly optically connected to the multi-mode optical waveguide (see claims 29-32); and/or wherein the light entering the multi-mode optical waveguide from the at least one optical waveguide (a) has the wavelength set forth in the independent claims (see claims 33-36); and/or wherein this wavelength is a single wavelength (see claims 37-40).

The present invention is directed to a light branching optical waveguide and optical device using the same, as well as a method of manufacturing such light branching optical waveguide. Such waveguide and device are used in optical transmission systems, and there has been a growing demand for such systems with the recent widespread use of personal computers and the internet.

An optical branching circuit and an optical multiplexing circuit serving as basic elements are indispensable to an integrated optical circuit, and an optical waveguide branched to provide a Y shape has been conventionally known. A multi-mode interference type Y branch optical waveguide has been known, and various kinds of such multi-mode interference type Y branch optical waveguides have been proposed, as discussed in the paragraph bridging pages 4 and 5 of Applicants' specification.

However, various problems arise in connection with such multi-mode waveguides. For example, an equal branching ratio of light is achieved only in the

case (1) where the mode of light propagating in the incident waveguide is a basic mode alone, (2) where the basic mode is symmetrical with respect to the central axis of the incident waveguide, (3) where the central axis of the incident waveguide and that of the multi-mode waveguide coincide with each other, and (4) where the multi-mode waveguide is of a shape symmetrical with respect to its central axis. In the case where the intensity distribution of light propagating in an optical waveguide on an incident side is asymmetric with respect to the geometrical central axis of the optical waveguide, there arises a problem that the branching ratio of light cannot be equal. Moreover, it is noted that when the incident light waveguide has a curvature, the basic mode is generally asymmetric.

Furthermore, in a multi-mode type light branching optical waveguide, the position at which light of a basic mode and light of a higher-order mode interfere with each other varies depending on a wavelength. Thus, there arises the additional problem that each of a loss of light intensity and a branching ratio is dependent on the wavelength. Accordingly, as the design of the multi-mode type light branching optical waveguide must be changed in accordance with the wavelength of the light, there arises a still further problem of, e.g., reduction of efficiency of production of the waveguide.

It is emphasized that various problems arise when the incident light waveguide has a curved structure. That is, and as described on pages 3 and 4 of Applicants' specification, when the incident optical waveguide has a curved structure, the case where the central axis of an optical propagation mode h of the intensity distribution of light and the geometrical central axis a of the incident light waveguide (core portion) 7 do not coincide with each other, as shown in Fig. 3 of

Applicants' disclosure, or the case where the intensity distribution of light is of a shape asymetrical with respect to the central axis h of the intensity distribution of light, as shown in Fig. 4, even though the central axis h of the intensity distribution of light and the geometrical central axis a of the incident light waveguide (core portion) 7 coincide with each other, occurs. In each of these cases, there arises a problem that the branching ratio of the light branching optical waveguide cannot be equal, even when offset structures as described in the paragraph bridging pages 2 and 3 of Applicants' specification is used.

On the other hand, when light propagating in an incident light waveguide has an intensity distribution (field distribution) of light asymmetrical with respect to the geometrical central axis of the incident light waveguide, making the shape of the distribution symmetrical requires a long straight-line portion, so there arises a problem in that the size of the module increases.

Against this background, and as described in the second full paragraph on page 7, and in the paragraph bridging pages 7 and 8, of Applicants' specification, the present inventors have found that a branch loss and a variation in branching ratio can be reduced, in structure wherein light of a basic mode propagates in the at least one incident light waveguide (A) (including at least one incident light waveguide (a) having a curvature) on the central axis of the multi-mode optical waveguide, by shifting position of the geometrical central axis of the optical waveguide (a) such that it does not coincide with the geometrical central axis of the multi-mode optical waveguide, and/or by making the core shape of the multi-mode optical waveguide asymmetrical with respect to the geometrical central axis of the multi-mode optical waveguide, even when the intensity distribution of light propagating in an optical

waveguide on an incident side is asymmetrical with respect to the geometrical central axis of the optical waveguide.

To emphasize, having investigated specific problems of branch loss and a variation in branching ratio, arising in connection with light branching optical waveguides using multi-mode optical waveguides and incident light waveguides wherein at least one of the incident light waveguides has a curved shape, and wherein light of a basic mode propagates in the at least one incident waveguide on the central axis of the multi-mode optical waveguide, Applicants have found structure which avoids these problems, achieving a light branching optical waveguide having a reduced branch loss and a reduced variation in branching ratio; and, additionally, provide structure wherein not only are such branch loss and variation in branching ratio reduced, but the light branching optical waveguide has a small wavelength dependency.

Thus, Applicants have found that, with light branching optical waveguide structure including at least one incident light waveguide that is curved and a multi-mode optical waveguide, as in the present claims, a branch loss and a variation in branching ratio can be reduced by an offset between the geometrical central axis of the incident light waveguide and the geometrical central axis of the multi-mode optical wavelength. Note the last full paragraph on page 16 of Applicants' specification.

Applicants have also found, as a further feature of the present invention, that by forming the core shape of the multi-mode optical waveguide to be asymmetrical with respect to the geometrical central axis of the multi-mode optical waveguide, light propagating in the multi-mode optical waveguide is provided with an intensity

distribution having two nearly equal peaks, so that the branching of light into the output light waveguides (B) at a branching ratio of 1:1 can be achieved.

In addition, as described in the paragraph bridging pages 19 and 20 of Applicants' specification, a low-loss, multi-mode, light branching optical waveguide having a reduced branch loss, a reduced variation in branching ratio and small wavelength dependence is achieved, where the extended line of the geometrical central axis of an incident light waveguide does not coincide with the geometrical central axis of the multi-mode optical waveguide, and the core shape of the multi-mode optical waveguide is asymmetrical with respect to the geometrical central axis of the multi-mode optical waveguide. Note, in particular, the paragraph bridging pages 20 and 21 of Applicants' specification.

Thus, note that the light branching optical waveguide of the present invention achieves branching of light to a branching ratio of 1:1 (equal) in the case that the light exhibits asymmetry in the incident waveguide. To accomplish this, it is important to change asymmetrical light of the optical waveguide (a) to a symmetrical light. A problem to be solved by the present invention is changing an asymmetrical light caused by optical waveguide (a), having the curved structure, to symmetrical light. This problem is solved by the present invention; i.e., by providing the branching ratio between the quantities of light branched into the two output light waveguides to be substantially equal, this means that the intensity distribution of light has been changed to symmetrical distribution.

It must be emphasized that according to the present invention, a low-loss light branching optical waveguide having a reduced branch loss and reduced variation in branching ratio is provided, even though the intensity distribution of light propagating

in an optical waveguide on an incident side is asymmetrical with respect to the geometrical central axis of the optical waveguide, e.g., due to the use of the curved incident optical waveguide (a).

Ido discloses an optical waveguide and a lightwave circuit. The structure includes an asymmetric Y branch optical waveguide including an input waveguide for entering light therein, two output waveguides for outputting the light therefrom, and a multi-mode waveguide which is disposed between the input waveguide and the two output waveguides and generates a plurality of mode lights therefrom, and wherein the multi-mode waveguide is made asymmetric with respect to a center line extending in the direction of an optical axis. Note column 2, lines 52-60.

Ido goes on to describe that the configuration of asymmetry can be obtained by various methods, the first being a method of setting the width of one of entrances or entrance portions of a multi-mode waveguide, which are divided by a center line so as to be smaller than that of its corresponding exit portion of the multi-mode waveguide; and the second being a method of setting the width of one of intermediate portions of the multi-mode waveguide, which are divided by the center line so as to be smaller than that of its corresponding exit portion of the multi-mode waveguide. This patent discloses that in each of these two techniques for obtaining the configuration of asymmetry, the exit portions of the multi-mode waveguide are set symmetrically with respect to the center line extending in the direction of the optical axis. See from column 2, line 61, through column 3, line 6, of Ido.

Note also column 3, lines 7-17, of Ido, describing an embodiment of another asymmetric Y branch optical waveguide, wherein distances between sides of core portions of the multi-mode waveguide and a center line differ from each other at least

at a portion with respect to the direction of traveling of the light. Note also column 3, lines 43-53 of Ido, describing use of the asymmetric Y branch optical waveguide in a lightwave circuit.

As applied by the Examiner, note Figs. 11 and 13 of Ido, and descriptions in connection therewith in column 8, lines 26-53, and column 20, lines 31-47.

Initially, and contrary to the contention by the Examiner in the second paragraph on page 4 of the Office Action dated September 3, 2009, it is respectfully submitted that this reference does not disclose, nor would have suggested, such structure, or the method of forming such structure, as in the present claims, including the at least optical waveguide (a), of the at least one incident light waveguide (A), having a curved structure; or problems arising in light thereof, and avoiding such problems as achieved by the present invention, including the structure and method defined in the present claims.

The comment by the Examiner in the second paragraph on page 4 of the Office Action dated September 3, 2009, referring to Embodiment 2 (Fig. 13) of Ido, as showing "optical fiber (303) which is shown to have a curved structure", is respectfully traversed. It is noted that Fig. 13 of Ido is a schematic structure, and it is respectfully submitted that the "circles" designated by the reference character 303 in Fig. 13 are a notation to show that the input optical fibers are very long. It is noted that the specification of Ido does not expressly teach, nor would have suggested, curved structure for the incident optical fiber. It is respectfully submitted that Ido has waveguides for input that have linear structure, especially referring to Figs. 1, 2 and 5-8 of Ido; it is also to be noted that Ido is silent with respect to an incident optical fiber being curved.

Furthermore, attention is respectfully directed to, e.g., Fig. 12 and the description in connection therewith at, e.g., column 19, lines 21-40 of Ido. Note especially the description therein that the asymmetric Y branch optical waveguide "indicates the one in which its branches are asymmetric with each other and its branching ratio is not given as 1:1". Note especially column 19, lines 35-40 of this patent. Clearly, this patent would have neither disclosed nor would have suggested, and in fact would have taught away from, such structure and method as in the present claims, including wherein the branching ratio between quantities of light branched into each of the at least two of the output light waveguides (B) is substantially equal. In this regard, it is emphasized that the object of Ido is to provide an asymmetric Y branch optical waveguide, directly opposite to that aspect of the present invention wherein a branching ratio between quantities of light branched into each of the at least two of the output light waveguides (B) is substantially equal.

The contention by the Examiner in the paragraph bridging pages 5 and 6 of the Office Action dated September 3, 2009, that the functional recitations of claims 1, 4, 7, 21, 24, 33, 35, 37 and 39 do not further distinguish or structurally limit any of the claimed structures of the claims, is noted. It must be emphasized that disclosed structure, to be anticipatory of the structure of the present claims, must be capable of achieving the branching ratio as in the present claims. In contrast, Ido expressly teaches that the asymmetric Y branch optical waveguide does not achieve a branching ratio of 1:1. Defining the structure of the present claims in terms of what it does, appropriate under 35 USC 112, it is respectfully submitted that Ido would have taught away from this feature of the present invention.

In view of the foregoing comments and amendments, and in view of the concurrently filed RCE Transmittal, entry of the present amendments, and reconsideration and allowance of all claims in the application, are respectfully requested.

To the extent necessary, Applicants hereby petition for an extension of time under 37 CFR 1.136. Kindly charge any shortage of fees due in connection with the filing of this paper, including any extension of time fees, to the Deposit Account of Antonelli, Terry, Stout & Kraus, LLP, Account No. 01-2135 (case 396.46073X00), and please credit any overpayments to such Deposit Account.

Respectfully submitted,

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